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## **SOLAR CELL TESTER REPEATABILITY MEASUREMENTS**

### **TEST OBJECTIVE:**

To determine the repeatability of the IV measurements of a Reference Cell as compared with the calibration values of the Reference Cell using Photo Emission Tech., Inc. (PET) CT150AAA system that was comprised of Model # SS150AAA Solar Simulator and CC-15 IV Measurement System with 15A maximum current measuring capability.

### **REFERENCE CELL DESCRIPTION:**

Device Manufacturer: VLSI Standards, Inc.  
Device Material: monocrystalline silicon  
Temperature Sensor: RTD  
Window Material: Quartz

This device was calibrated to a Master Reference Cell calibrated by National Renewable Energy Laboratory, Golden, CO, USA. The certified values and extended certainties under Standard Test Conditions (STC) were specified and are shown in the attached table in the blue shaded cells. These certified values and uncertainties are traceable to the International System of Units (SI).

### **PET EQUIPMENT:**

1. Model # SS150AAA Solar Simulator
2. Model # CC-15, IV Measurement System with 15A maximum current capability.

### **TEST DESCRIPTION:**

The Solar Simulator and the IV Measurement System was calibrated prior to start of the test sequence. The system calibration was not changed or verified throughout the duration of the tests. Each test sequence consisted of ten (10) measurements of the Reference Cell. Ten (10) sequences were performed over a period of eight (8) days. Averages of the ten (10) measurements of each test sequence were calculated. These averages are shown in the attached tables in the cells as Test1 through Test10.

Grand average of all these averages were then calculated. These averages,  $\pm 3$  standard deviations and Coefficient of Variations are shown in cells highlighted in yellow.

### **TEST DATA:**

See data sheets Page 3 for detailed test results.

## DISCUSSION OF TEST RESULTS:

Even though there were differences in the Reference Cell temperature during measurements (average of 24.75°C and the temperature at the time of calibration (22.1°C), the measured results compared very well with the calibration values and its uncertainties.

The grand average of the measured  $I_{SC}$  (Short Circuit Current) was 127.35mA,  $\pm 1.72$ mA as compared with the calibrated value of 126.4mA,  $\pm 1.8$ mA.

The grand average of the measured  $V_{OC}$  (Open Circuit Voltage) was 595.01mV,  $\pm 2.68$ mV as compared with the calibrated value of 597.5mV,  $\pm 3.4$ mV.

The grand average of the measured  $I_M$  (Maximum Current) was 116.75mA,  $\pm 1.71$ mA as compared with the calibrated value of 115.7mA,  $\pm 1.7$ mA.

The grand average of the measured  $V_M$  (Maximum Voltage) was 488.06mV,  $\pm 1.91$ mV as compared with the calibrated value of 494.0mV,  $\pm 4.2$ mV.

The grand average of the measured  $P_M$  (Maximum Power) was 56.98mW,  $\pm 0.73$ mW as compared with the calibrated value of 57.2mW,  $\pm 1.0$ mW.

The grand average of the measured FF (Fill Factor) was 0.75,  $\pm 0.0$  as compared with the calibrated value of 75.7,  $\pm 0.8$ .

The grand average of the measured Efficiency was 14.15%,  $\pm 0.21$ % as compared with the calibrated value of 14.3%,  $\pm 0.2$ %.

The grand average of the measured Intensity was 1005.04 W/m<sup>2</sup>,  $\pm 7.92$  W/m<sup>2</sup> as compared with the calibrated value of 1000.00 W/m<sup>2</sup> with no uncertainty specified.

## CONCLUSION:

Based on these test results it can be concluded that CT150AAA system's measurement repeatability is excellent.

The main differences between the measurement conditions and calibration conditions were the level of irradiance and the actual cell temperature. The differences in the average measured values as compared to the calibrated values can be attributed to these two factors. PET IV Software has the ability to correct the measured values to the Standard Test Conditions (STC) or user specified conditions. If the STC correction is applied to the measurement results, then the average measured values are expected to be even closer to the calibrated values.

In most cases, the variation in measured values is as good or better than the variation in the calibration values.

SOLAR CELL TESTER REPEATABILITY TEST										
20-Sep-10										
Average of PET Measurements of VLSI Reference Cell										
Test #	Date	Tc [degC]	Isc [mA]	Voc [mV]	Im [mA]	Vm [mV]	Pm [mW]	FF [-]	Eff [%]	Intensity (W/m <sup>2</sup> )
1	09/22/10	24.72	127.48	595.27	116.96	488.10	57.08	0.752	14.21	1003.52
2	09/23/10	24.72	127.80	594.73	117.33	486.96	57.17	0.752	14.20	1005.07
3	09/24/10	24.76	128.82	594.78	118.19	487.81	57.67	0.753	14.33	1004.89
4	09/27/10	24.80	127.85	597.06	117.27	488.27	57.27	0.750	14.13	1010.36
5	09/29/10	24.82	128.31	594.18	117.50	487.70	57.30	0.752	14.13	1010.43
6	09/30/10	24.74	126.98	594.88	116.37	488.79	56.87	0.753	14.13	1007.49
7	09/30/10	24.73	127.35	594.36	116.55	488.96	56.98	0.753	14.13	1006.83
8	10/01/10	24.78	127.69	595.34	116.97	488.32	57.11	0.751	14.13	1009.39
9	10/03/10	24.73	126.02	593.62	115.37	488.27	56.34	0.75	14.09	998.44
10	10/03/10	24.73	125.23	595.86	114.95	487.46	56.02	0.75	14.07	993.96
Grand Average of PET Measurements of VLSI Reference Cell										
	<b>Avg</b>	24.75	127.35	595.01	116.75	488.06	56.98	0.75	14.15	1005.04
	<b>±</b>	0.11	1.72	2.68	1.71	1.91	0.73	0.00	0.21	7.92
	<b>CV</b>	0.46%	1.35%	0.45%	1.47%	0.39%	1.28%	0.36%	1.48%	0.79%
VLSI Reference Cell Calibration Value										
	<b>Avg</b>	<b>22.1</b>	126.4	597.5	115.7	494	57.2	75.7	14.3	1000
	<b>±</b>	<b>1</b>	1.8	3.4	1.7	4.2	1.00	0.8	0.2	
	<b>CV</b>	4.52%	1.42%	0.57%	1.47%	0.85%	1.75%	1.06%	1.40%	